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Atty. Docket No. MTKI-04-332A-1
Serial No: 09/401,132

Remarks

Claims 31 and 50 have been canceled. Thus, Claims 22-30 and 32-49 are active in the present application.

The present invention relates to a method for allocating bits to encode each frame of an image sequence, where each frame has a plurality of objects. The invention further relates to an apparatus for encoding each frame of such an image sequence, as well as a computer-readable medium having stored thereon a plurality of instructions which, when executed by a processor, perform the steps of the method. The method (as set forth in amended Claim 22 above) generally comprises:

(a) determining a target frame bit rate, T_{frame}, for the frame in accordance with a quantizer scale for each object in the frame;

(b) allocating the target frame bit rate among the plurality of objects in accordance with the formula:

$$V_i = K_i \times T_{frame}$$

where V_i is a target object bit rate for each object, and K_i is proportional to an average pixel value for the object; and

(c) recursively adjusting the target frame bit rate for each frame in the sequence.

In further embodiments, the present invention relates to a computer-readable medium (containing instructions to perform the present method; see amended Claim 32 above), and an apparatus for encoding each frame of an image sequence. The apparatus (as set forth in amended Claim 29 above) generally comprises:

(a) a motion compensator for generating a predicted image of a current frame;

(b) a transform module for applying a transformation to a difference signal between the current frame and the predicted image, where the transformation produces a plurality of coefficients;

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(c) a quantizer for quantizing the plurality of coefficients with at least one quantizer scale; and

(d) a controller for selectively adjusting the at least one quantizer scale for a current frame in response to a target object bit rate for each of the plurality of objects, and for determining the target object bit rate from a target frame bit rate in accordance with the formula:

$$V_i = K_i \times T_{frame}$$

where V_i is a target object bit rate for each object, and K_i is proportional to an average pixel value for the object.

The primary reference cited against the claims (Eleftheriadis et al., U.S. Pat. No. 6,055,330 [hereinafter "Eleftheriadis"]) does not disclose allocating a target frame bit rate among the objects in a frame according to an average pixel value for the object, nor does Eleftheriadis et al. appear to disclose the present recursive adjustment step (see amended Claim 22). While Eleftheriadis mentions the quantization of pixels and frames that comprise a plurality of objects, one benefit of the present claimed method is that the target bit rates can be prioritized based on the relative need of the objects for the available bits (as reflected by the average pixel value) in a given application, rather than on the size of the objects. Furthermore, Eleftheriadis does not disclose a controller for determining the target object bit rates from a target frame bit rate in accordance with an average pixel value for the objects (see Claim 29). Consequently, the present claims are patentable over the cited references.

Thus, an advantage of the presently claimed invention is that an object having a smaller number of pixels, but needing more bits (e.g., in terms of encoding syntax information, motion information and/or shape information; see, e.g., page 14, lines 2-7 of the present specification), can have a greater proportion of the available bandwidth, or target frame bit rate, than a larger object that does not need as many bits. In contrast, the approach of Eleftheriadis appears to assign a certain proportion of the available frame bandwidth based solely on the size of the object, without reference to the relative need for encoding bits by the various objects in the frame. The secondary reference, Klein Gunnewiek, fails to cure this deficiency.

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Claim Rejections under the Judicially Created Doctrine of Double Patenting

Applicants provisionally agree to file a terminal disclaimer to overcome the non-statutory double patenting rejection of claims 22-24, 27-34 and 37-38. In particular, Applicants will file the terminal disclaimer if and when all of the other claim rejections have been resolved.

The Rejection of Claims 22-30 and 32-50 under 35 U.S.C. § 103(a)

The rejection of claims 22-30 and 32-50 under 35 U.S.C. § 103(a) as being unpatentable over Eleftheriadis (U.S. Pat. No. 6,055,330) in view of Klein Gunnewiek (U.S. Pat. No. 5,606,371) is respectfully traversed.

Eleftheriadis discloses a method and apparatus for performing digital image and video segmentation and compression using 3-D depth information (Title). In contrast to the present claims 22 and 32, which recite allocating the target object bit rate(s) in accordance with the target frame rate and an average pixel value for the object, Eleftheriadis appears to determine a target object bit rate based on a quantizer (the value of which appears to be related to the distance of the object from the camera; see, e.g., col. 11, ll. 1-15 and 41-44) and the proportion of pixels in the object (see, e.g., col. 11, l. 65-col. 12, l. 10). Thus, Eleftheriadis is deficient with respect to the present claims.

For example, Eleftheriadis teaches that the frame bit rate is given (e.g., determined *a priori*, and apparently dependent on the bandwidth of the channel which is accepting data from the buffer; see p. 9 of the Amendment filed December 15, 2005). Thus, Eleftheriadis appears to be silent with regard to recursively adjusting a target frame rate, as recited in claims 22 and 32. Furthermore, the rate control performed by placing a buffer 320 at the output 310 of the variable bit rate (VBR) encoder 200 and having a rate controller 340 takes into account the occupancy of the buffer and other parameters that are possibly signal dependent in order to decide the quantizer step size in quantizer 251, so that the buffer does not overflow or underflow (col. 8. ll. 17-27, and Fig. 2-3). This technique as taught by Eleftheriadis only describes a feedback mechanism where the rate controller processes the output parameters ***of the buffer*** to adjust the

encoding rate (Fig 3). It cannot be reasonably interpreted as recursively adjusting the target frame bit rate for each frame in an image sequence, as recited in the present claims 22 and 32. Therefore, Eleftheriadis is deficient with respect to the recitation of "recursively adjusting the target frame bit rate for each frame in the sequence" in the present claims 22 and 32.

Furthermore, Eleftheriadis fails to disclose allocating a target frame bit rate among a plurality of objects in accordance with the formula $V_i = K_i \times T_{frame}$, where V_i is a target object bit rate for each object, and K_i is proportional to ***an average pixel value*** for the object.

Eleftheriadis discusses two coding techniques for controlling bit rates, variable bit rate (VBR) coding and constant bit rate (CBR) coding (see col. 8, ll. 8-19 and col. 11, ll. 39-64). Eleftheriadis discloses a constant bit rate encoder (FIG. 10), in which an object map generated by object segmentation circuit 500 is received by a macroblock labeling circuit 1100 (see col. 10, l. 65-col. 11, l. 1). Since the encoder splits each frame of video information received from the camera into macroblocks and quantizes DCT coefficients on a macroblock basis, Eleftheriadis teaches that it is desirable to assign each macroblock of video data to a specific object, or in the case of a simple segmentation technique described therein, to a region which contains one or more objects at the same depth from the camera (col. 11, ll. 1-8). Once the macroblock including pixels from an object or region has been assigned, it will be assigned to one object or region by macroblock labeling circuit 1100, a rate controller 1040 can select an appropriate quantizer step size for the entire current macroblock (col. 11, ll. 12-15).

For CBR coding, the rate controller 1040 must additionally regulate quantizer selection so that the output buffer 1020 neither overflows nor underflows. ***Since the total number of bits per second which may be output is now fixed***, object sizes become important (col. 11, ll. 53-57; emphasis added). In accordance with a known technique for performing area-selective rate control when the object locations are known, each object is associated with a particular target average bit rate R_i, except for the background (object n). Thus, in CBR coding, Eleftheriadis appears to determine a target object bit rate based on a quantizer value, rather than an allocation in accordance with the target frame rate, as recited in the present claims 22 and 32.

In order to maintain the given total average rate R necessary to prevent buffer overflow, the background rate is determined according to EQ. (4):

$$\sum_{i=0}^{n} a_i R_i = R \qquad (4)$$

where a_i is the proportion (from 0.0 to 1.0) of the pixels in the frame that belong to object i (col. 11, l. 67-col. 12, l. 10; emphasis added). Thus, Eleftheriadis determines a target object bit rate based on ***the proportion of pixels in the object***, rather than an average pixel value for the object. Thus, Eleftheriadis is deficient with respect to the present claims.

Eleftheriadis explicitly teaches that it is possible that R_n (the background bit rate) is negative (col. 12, l. 16). To one of ordinary skill in the art, this possibility of a negative background bit rate demonstrates that target object bit rates are not allocated in accordance with a target frame rate. Rather, they must be determined by some other technique (such as in accordance with a quantizer value, as explained above, which in turn appears to be based on the occupancy B_{max} of a buffer [col. 3, ll. 22-26], the output rate of which is constant and dependant on the bandwidth of the channel which is accepting data from the buffer; see col. 3, ll. 17-22). Eleftheriadis further teaches that the possibility of a negative background bit rate may simply have the effect of assigning as coarse quantization as possible to the background, and may result in less average bits per second per object than the target bit rates R_i indicate (col. 12, l. 16-19), further confirming that ***target*** object bit rates therein are not allocated in accordance with a target frame rate.

Thus, there appears to be no reasonable basis in Eleftheriadis for an assertion that EQ. (4) is used to determine the target frame rate; to the extent R may be related to a target frame rate, Eleftheriadis teaches that it is given (as discussed in the preceding paragraph, dependent on the bandwidth of the channel which is accepting data from the buffer). Consequently, in the relevant discussion of CBR coding, Eleftheriadis fails to disclose step of allocating the target frame bit rate in accordance with a target object bit rate as presently claimed.

Also, as discussed above, since Eleftheriadis teaches that the frame bit rate is related to the occupancy of a buffer having a constant output rate that is, in turn, dependent on the bandwidth of the channel which is accepting data from the buffer, Eleftheriadis cannot disclose or suggest to one of ordinary skill in the art that the frame bit rate can be (much less should be) adjusted. Thus, Eleftheriadis appears to be silent with regard to recursively adjusting a target frame rate, as recited in claims 22 and 32.

For VBR coding, Eleftheriadis teaches that macroblock labels can be directly used for rate control by associating particular quantizer step sizes with each object (col. 11, ll. 39-41). The encoder can also employ techniques to "smooth out" quantizer differences at object boundaries by gradually changing the quantization step while entering or exiting an object (col. 11, ll. 47-50). A macroblock labeling circuit 1100 (see FIG. 11) contains object identifications for each pixel in the macroblock (col. 11, ll. 16-19), and quantizer selection is simply a lookup operation into a table which indexes the possible object identifications generated by macroblock labeling circuit 1100 (col. 11, ll. 44-47). Also, Eleftheriadis teaches that rate control is also usable in a purely VBR encoder to provide higher quality for some image areas, and less for areas that have smaller significance (e.g., background areas). As a result, the term rate control is used by Eleftheriadis generally without discriminating whether or not a CBR or VBR encoder is used (col. 8, ll. 40-47). Thus, the discussion of VBR coding by Eleftheriadis fails to cure any deficiency of Eleftheriadis with regard to the allocating step in the present claims 22 and 32.

Consequently, Eleftheriadis fails to disclose the steps of (i) allocating the target frame bit rate in accordance with an average pixel value for the object and (ii) recursively adjusting the target frame bit rate, as presently recited in claims 22 and 32. As such, Eleftheriadis does not anticipate the present claims 22 and 32. Therefore, this ground of rejection should be withdrawn with regard to claims 22, 32, and claims dependent therefrom.

Furthermore, Eleftheriadis fails to disclose the controller of claim 29, which determines the target object bit rate from a target frame bit rate in accordance with an average pixel value for each of the objects. As discussed above, Eleftheriadis determines a target object bit rate based on ***the proportion of pixels in the object***, rather than an average pixel value for the object. In

addition, Eleftheriadis discloses a rate controller 1040 that regulates quantizer selection so that the output buffer 1020 neither overflows nor underflows (col. 11, ll. 53-57). However, the output rate of the buffer is constant and dependant on the bandwidth of the channel which is accepting data from the buffer (see col. 3, ll. 17-26). Eleftheriadis does not appear to disclose any connection between the bandwidth of the channel which is accepting data from the buffer and a target frame bit rate. As a result, Eleftheriadis is deficient with regard to the present claim 29.

Klein Gunnewiek discloses a device for encoding a video signal comprising means for dividing each picture into a plurality of sub-pictures, an encoder comprising a picture transformer for transforming each sub-picture into coefficients, and a quantizer for quantizing the coefficients with an applied step size (col. 1, ll. 5-10). Klein Gunnewiek neither discloses nor suggests allocating a target frame bit rate among the object(s) in a frame according to an average pixel value for the object, nor recursively adjusting the target frame bit rate for each frame in the sequence. The derivation of target frame rates from the equation of different targeted frames and pictures as taught by Klein Gunnewiek cannot be reasonably interpreted as allocating a target frame bit rate among the objects in a frame (or determining the target object bit rate from a target frame bit rate) in accordance with an average pixel value for the object. Thus, Klein Gunnewick fails to cure the deficiencies of Eleftheriadis with respect to allocating the target frame bit rate among the objects in each frame in accordance with the formula $V_i = K_i \times T_{frame}$, where V_i is the target object bit rate for each object, and K_i is proportional to an average pixel value for the object, and recursively adjusting the target frame bit rate for each frame in the sequence, as recited in claims 22 and 32. Similarly, Klein Gunnewiek fails to cure the deficiencies of Eleftheriadis with respect to or determining the target object bit rate for each of a plurality of objects in a frame from the target frame bit rate, as recited in the present claim 29. Consequently, no possible combination of Eleftheriadis and Klein Gunnewiek can suggest the present claims 22, 29 and 32.

As a result, this ground of rejection is unsustainable, and should be withdrawn.

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Conclusions

In view of the above amendments and remarks, all bases for rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,

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